



3.2 SEDIMENT

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3.2.1 Introduction

Sediment transported from upslope areas into stream channels can adversely affect the hydrologic system and its beneficial uses, such as fish habitat and water quality. In addition, sediment transport in the form of landslides can adversely affect public safety. Sediment enters water through various processes including surface erosion, channel erosion, and mass movements, and these inputs can be either chronic or episodic. This section discusses the management-related impacts that can influence sediment delivery to streams.

3.2.2 Affected Environment

Sediment delivery rates are controlled by watershed characteristics such as geology, topography, vegetation, and hydrology. As a result there is equilibrium between sediment input and sediment routing that must be maintained to have a healthy stream system (Everest et al., 1987). Sediment inputs are a combination of fine sediment, coarse sediment, and larger elements of instream structures, such as boulders and large wood. In undisturbed basins, most natural sediment production occurs from streambank erosion,



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debris slides followed by debris flows, tree blowdown, and animal burrows. Forest practices, through the alteration of soil structure, vegetation, and hydrology, can significantly alter the delivery of fine and coarse sediment to streams, thereby potentially adversely affecting the beneficial uses of the stream network. The primary management-related sources of sediment are surface erosion and mass wasting from timber harvest activities and roads.

To effectively discuss the effects of forest practices on sediment production in forested environments, it is important to have an understanding of the major management activities that contribute sediment to the drainage network.

3.2.2.1 Road-related Sediment

Surface Erosion

Road-related surface erosion is a function of sediment available for movement and the power of water available to move it. Road construction, use, maintenance, abandonment, and drainage all play important roles in the production and delivery of sediment. Surface erosion from roads tends to be a chronic source of fine sediment to the drainage network. Chronic sources of fine sediment can adversely impact the physical habitat of the aquatic system and certain lifestages of fish and amphibians, and also degrade water quality. Delivery of fine sediment to streams from roads is a major concern because of the thousands of miles of forest roads that exist to transport harvested timber in forested regions of the state. Appendix F, Forest Roads evaluates the specific best management practices (BMPs) of each alternative and should be consulted for further details.

Road-Related Landslides

Landslides are episodic sources of fine and coarse sediment to the aquatic system. A landslide is the mass movement of soil, rock, and debris downslope; it occurs most frequently after heavy winter rains. Landslide activity can be greatly accelerated by road management practices. Many studies have shown that on a unit area basis, roads have the greatest effect on slope stability of all activities on forestlands (Sidle et al., 1985). However, some recent research suggests that harvest-related landslides occur with roughly equal frequency as road-related landslides (Montgomery et al., 1998).

Road location, drainage, design, construction, and maintenance are all-important factors in effective road design, but can be contributing factors to road-related failure. Newer road construction and engineering design has reduced road-related landslides relative to roads constructed more than 15 to 20 years ago (Toth, 1991; Robison et al., 1999). Road-related landslides can become debris torrents and impact stream channels.

Orphan Roads

For the purpose of this analysis, orphan roads are roads constructed prior to 1974 that have not been used for forest practices since that time. Such roads are typically not maintained and many were constructed without a requirement to consider public resource and channel impacts. The mileage of orphan roads in the state is unknown; however, the associated hazards have been identified. The concern with orphan roads is the potential for failure and initiation of debris flows and torrents.



3.2.2.2 Sediment Related to Timber Harvest

Timber harvest-related sediment can be delivered to the aquatic system as short-term surface erosion (fine sediment) generated from harvest units and skid trails, or it can be episodic from landslides initiated in harvested areas on unstable slopes. Timber harvest activities often alter watershed conditions by changing the quantity and size distribution of sediment that can lead to stream channel instability, pool filling by coarse sediment, or introduction of fine sediment to spawning gravels.

Surface Erosion

Surface erosion is dependent on many variables. The primary variables are slope, soil texture, and vegetation cover (Benda et al., 1995). Harvest activities such as ground skidding or cable yarding can cause some degree of soil disturbance. Typically, ground-based systems compact and disturb more soils than non ground-based harvest systems (Graham et al., 1990). The harvest systems most likely to cause greater levels of disturbance (from greatest to lowest) are ground-based systems, cable yarding, and aerial systems (Beschta, 1995). Clearcuts tend to create the greatest area of soil disturbance (Hermann, 1978); however, disturbance from felling, yarding, and skid trails in partial cuts can also cause ground disturbance and compaction. Cromack et al. (1978) found levels of soil disturbance in clearcut and partial cut areas to be comparable because of the need for equivalent access through a harvest unit. Accelerated rates of erosion are generally not prolonged for more than several years as areas revegetate (Beschta et al., 1995). Fine sediment that is transported overland can be significantly reduced by streamside buffer strips. The ability of riparian buffer strips to control sediment inputs from surface erosion depends on several site characteristics including the presence of vegetation or organic litter, slope, soil type, and drainage characteristics. Additionally, the filtering capacity is affected by timber harvest activities within the buffer. Although soil disturbance generally increases the sediment delivery potential, the addition of obstructions on the forest floor from tree limbs and boles associated with partial logging can offset diminished filtration (Burroughs and King, 1989; Benoit, 1979).

Mass Wasting

LANDSLIDES

Landslides tend to be the dominant natural erosion mechanism in areas with steep slopes throughout the Pacific Northwest (Swanson et al., 1987). Landslides are an important disturbance mechanism to riparian areas and are episodic sources of predominantly coarse and fine sediment to the drainage network of a watershed. Generally, less than 2 percent of the land is directly affected by landslides at any given time (Ketcheson and Froelich, 1978; Ice, 1985). Debris slides are the most common landslides on steep forest lands. Major storms increase the rate and intensity of landslides. Sidle et al. (1985) summarized several studies (Swanston, 1970, 1974; O'Loughlin, 1974; Ziemer and Swanston, 1977; Burroughs and Thomas, 1977; Gray and Megahan, 1981; Ziemer, 1982) indicating that stability depends partly on reinforcement from tree roots, especially when soils are partly or completely saturated.



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DEBRIS TORRENTS

Landslides can turn into debris torrents, which are classified as debris flows (approximately 80 percent solid and 20 percent water) or hyperconcentrated floods (about 80 percent water and 20 percent solid), depending on site characteristics and conditions at the time. Debris flows usually transport more material than the initiating event, due to scouring action on the slope or in the channel. Debris flows stop moving when the slope gradient of the channel decreases or when the flow encounters a sharp bend in the channel. Debris torrents contain significant amounts of wood and can travel varying distances, which can result in variable degrees of impact depending upon channel gradient, confinement, layout of the channel network, and other characteristics (Fannin and Rollerson, 1993). Debris torrents and debris flows can have significant, long-lasting effects on stream channels. The channel location and cross-section can be radically altered in such a way that normal flows and normal peak flows cannot reconfigure the channel easily (Lamberti et al., 1991). This is important because even though landslides in general may affect only one percent of a watershed, debris flows and torrents can affect 10 percent of the stream system because of their mobility (Swanson et al., 1987). In addition to having significant impacts on the stream channel, debris torrents can also affect riparian buffer functions and streamside forests when bank scour is so great that streamside vegetation is removed (see discussion on streambank stability).

STREAM BANK STABILITY

The roots of riparian vegetation help bind soil together, which make stream banks less susceptible to erosion. The stability of stream banks is largely determined by the size, type and cohesion of bank material, vegetation cover, and the amount of bedload carried by the channel (Sullivan et al., 1987). Riparian vegetation can also provide hydraulic roughness elements that dissipate stream energy during high or overbank flows, which further reduces bank erosion. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity (FEMAT, 1993); however, in wide valleys with shifting stream channels, vegetation throughout the floodplain or CMZ may be important over longer time periods.

3.2.2.3 History of Forest Practices Affecting Sediment Production

Prior to the adoption of the Washington Forest Practices Act in 1974, there were few rules or regulations that governed timber management activities on state and private forest lands. In early years, streams were used to move logs downstream to accumulation sites. Most streams of sufficient size in western Oregon and Washington were cleared of obstructions for log drives during high water (Sedell et al., 1991). On streams too small for log drives, splash dams of log cribbing were used to raise a head of water for sluicing logs (Sedell and Luchessa, 1982). By about 1900, over 300 major splash dams and many undocumented smaller dams operated in Oregon and Washington.

Railroads were built along the mainstems of the larger drainages, and logs were yarded down the smaller tributaries to the rail bed. In this way, impacts extended to intermittent channels. Whole watersheds were logged as convenience dictated beginning in the lower watershed and progressing upstream until all valuable timber was taken. Logs were yarded



downhill, scraping debris and sediment into stream channels. Streams were protected from being used for yarding beginning in the 1950s. Clearcutting to the streambank, however, was normal practice until the 1980s.

Timber harvest and associated road building can lead to increased rates of erosion into stream channels, which can alter substrate composition within the channels. Channel disruption, decreased rooting strength, removal of debris from channels, and elevated sediment loading decrease the stability of channel morphology and the stream substrates (Gregory et al., 1987). Roads were constructed on unstable slopes with substandard construction techniques compared to today's practices. The result is a legacy of roads that continue to be sources of chronic and episodic sediment into the drainage network. In addition, there were few restrictions on harvest unit size. The proportion of sediment contributed from different timber harvest activities varies between areas. Some studies have shown that landslides related to timber harvest contribute more sediment on a watershed basis, than landslides associated with roads (e.g., Paulson, 1997), while other studies indicate that roads contribute more sediment, through both landslides and surface erosion (Ice, 1985). Differences in lithology, soils, style of timber harvest, and road age may be responsible for this variation.

Furthermore, the effects of debris torrents and debris flows originating from harvested areas may be more damaging than such landslides originating from mature forest. Reynolds and Paulson (1997) documented that the run-out along stream channels of debris flows which originated in harvested areas, was twice as long as those landslides originating in mature forest. Buffers intended to minimize landsliding and provide a fencing effect may be compromised by short-term losses to wind; therefore, the ability of a buffer to withstand blowdown is an important aspect of its effectiveness. In a detailed study of four dam-break floods, Johnson (1991) found that the width of damage to riparian stands averaged 75 feet and ranged from less than 33 feet to 197 feet (depending on channel slope and valley width).

The legacy of these past practices can be observed on the hillslopes of many managed-forested areas. Road construction associated with timber harvest activities began before 1950, with many areas thoroughly harvested prior to that time. Many of the roads used before the advent of forest practices rules were no longer in use by 1974. These old roads, called orphan roads, have been recognized as potential hazards to public resources and public safety (Brunengo and Bernath, 1990). Since the establishment of forest practices rules and the requirements of the Clean Water Act, rules and BMPs were implemented to guide timber harvest methods and new road construction.

3.2.2.4 Existing Conditions Related to Sediment Production

In a DNR unpublished draft document on forest roads (DNR, unpublished draft report, 1999), significant amounts of sediment entering the drainage network were documented in 70 percent of the sub-basins reviewed. The survey was conducted on 380 miles of forest roads on 113 square miles of various private and public lands on 23 westside sites and 11 eastside sites. Maintenance issues and rule language that does not address sediment delivery during road construction and maintenance were concluded to be the major factors



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contributing to the current state of road surface erosion and road-related mass wasting in Washington. The findings of the DNR survey include:

- Landslides were identified in half of the survey areas, with some areas delivering large amounts of sediment to perennial streams.
- Approximately 65 percent of the survey areas had direct delivery of sediment from roads to streams.
- Culverts were a problem in 90 percent of the sub-basins.
- Individual roads can exceed natural sediment input levels by 40 times.
- Road drainage ditches were a problem in 66 percent of the sub-basins.
- Commonly used road maintenance techniques are inadequate.
- Watershed analysis and road maintenance plans assist landowners in identifying and correcting resource issue.

The forested environment includes steep slopes or specific landforms that have a greater potential to fail, especially if disturbed by management activities. High and moderate hazard unstable slopes are defined as areas that have the greatest potential for mass wasting. Approximately 9 percent of the eastside and 18 percent of the westside consist of unstable slopes with a high or moderate potential to deliver sediment to streams (see Appendix E for more information).

3.2.3 Environmental Effects

In describing the environmental effects of sediment, it is best to separate the discussion according to the primary sources of management-related sediment -- roads and timber harvest. This discussion is presented in the following sections.

3.2.3.1 Evaluation Criteria

A number of evaluation criteria have been identified to evaluate the degree of protection from sediment impacts offered by each of the alternatives. Both quantitative and qualitative criteria are necessarily included. These criteria are defined in greater detail in Appendix B. Quantitative analysis of many of these criteria are provided in Appendix D (Riparian Habitat Analyses), Appendix E (Slope Stability Analysis), and Appendix F (Forest Roads).

Road Surface Erosion

As described in Section 3.2.2, road surface erosion is affected by road construction methods, road use, road maintenance, road abandonment, and drainage. The criterion for evaluating this chronic source of sediment impacts is how the forest practices rules that define road management (i.e., planning, construction, use, maintenance, drainage, and abandonment) under each alternative, control road-related sediment production and delivery to streams (see Appendix F).

Road-related Landslides

The potential for road-related landslides depends on both the location of roads in relation to unstable areas and on how the roads are designed, built, and maintained. Therefore, the



evaluation criteria for this episodic source of sediment impacts are: (1) the degree that unstable slopes would be avoided under each alternative; and (2) the degree of protection from road-related landslides provided by the forest practices rules (see Appendices E and F).

Hillslope Erosion Related to Timber Harvest

The disturbance of soil on hillslopes from timber harvest activities can result in short-term surface erosion that can be generated until vegetation is reestablished. The potential for delivery of fine sediment to streams is dependent upon the amount of ground disturbance and the interception of potential overland flow. The evaluation criteria for harvest-related sediment is the amount of harvest and hillslope-related surface erosion that reaches stream channels through riparian buffers. In Section 3.2.3.2, the width of RMZs is compared to a buffer width of 30 feet. Then the activity allowed in the RMZ is evaluated by using the results of the equivalent buffer area index (EBAI) for sediment (see Appendix D) and by assessing BMPs within the RMZ.

Landslides Related to Timber Harvest

Harvest-related mass wasting is most likely to occur on steep slopes and specific landforms that are highly susceptible to mass failure. The initiation of failures from management activities can occur near streams within riparian areas and upslope areas. Buffers intended to protect slope stability (in addition to other functions) and provide a fencing effect may be compromised by short-term losses to wind; therefore, the ability of a buffer to withstand blowdown is an important aspect of its effectiveness. The evaluation criteria for harvest-related landslides is the degree of protection provided to unstable areas by forest practices rules. These criteria include protection of unstable slopes upslope from RMZs that may buffer upslope landslides, landslides that may occur in RMZs, and debris torrent initiation areas that are likely to deliver sediment to the channel, and buffer effectiveness (see Appendix E).

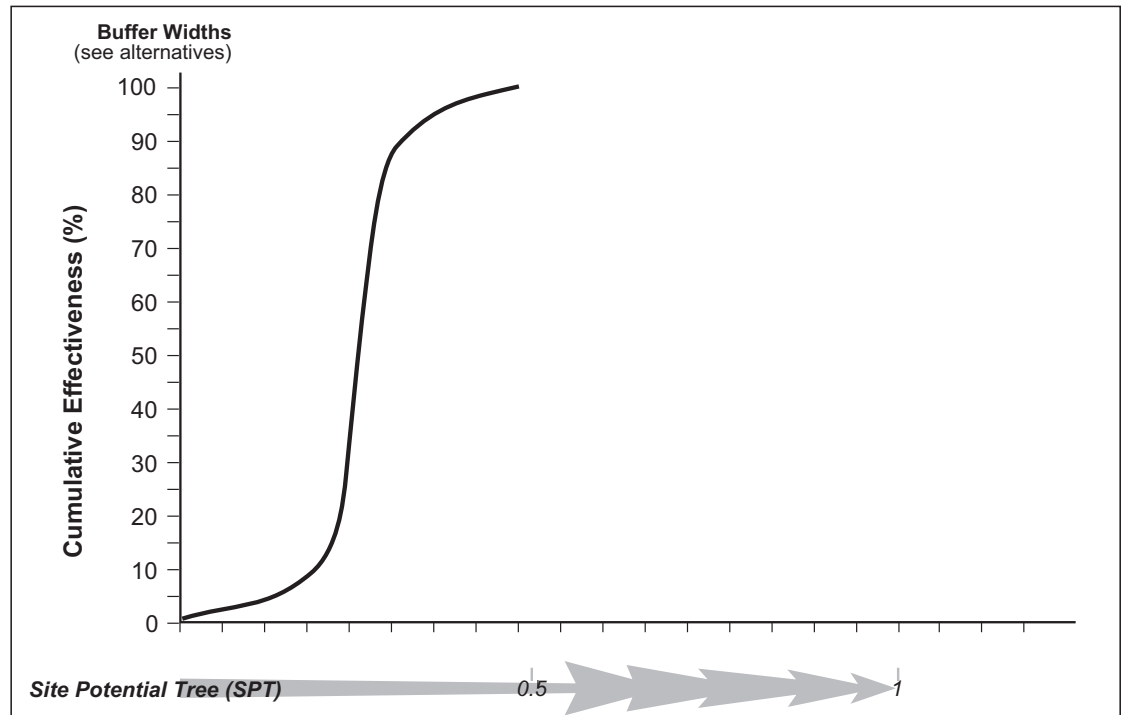
Bank Stability

This evaluation is based on width of the respective RMZs and activities allowed within the buffer that may affect root strength and, thus, stream bank integrity. For this analysis, one-half of a tree crown diameter (or its equivalent 0.3 of a site-potential tree height [SPTH], based on 100 to 250 years) is assumed to provide complete protection of bank stability (Spence et al., 1996), though it is realized in certain channels, particularly bedrock controlled channels, a much narrower RMZ would be required to maintain bank stability. The full estimated relationship between bank stability protection and SPTH is shown in Figure 3.2-1.

Figure 3.2-1. Percent Effectiveness of Root Strength in Relation to the Distance from the Stream Channel



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Source: FEMAT, 1993

Figure 3.2-1

The Percent Effectiveness of Root Strength in Relation to the Distance from the Stream Channel



3.2.3.2 Alternative Evaluation

Road Surface Erosion

ALTERNATIVE 1

Alternative 1 would result in a high risk of fine sediment delivery to streams, primarily because the rules do not directly address the desired outcome; therefore, they lack the needed flexibility for site-specific situations. In addition, RMAPs are not generally required and rules and BMPs that address road drainage are inadequate. The risk of sediment delivery is substantially reduced with watershed analysis.

Under Alternative 1, the forest practices rules are intended to reduce the risk of sediment delivery to streams based on implementation of BMPs. As discussed in Appendix F, there is a high risk of sediment delivery to streams from roads, under Alternative 1. This was confirmed in a published study by Rashin et al. (1999) who evaluated the BMPs in the current forest practices rules. However, where watershed analysis had been applied, prescriptions were developed to reduce surface erosion for areas where there was a high vulnerability to a public resource, such as fisheries or water quality.

A road maintenance survey was conducted by the DNR on 379 miles of forest roads across the state. The unpublished draft document concluded that the rules under Alternative 1 are subjective and inadequate because they do not establish an acceptable limit on how much sediment delivery constitutes resource damage. The delivery of fine sediment from the road surfaces to streams are addressed by the rules with statements such as “minimize erosion” or “not conducive to accelerated erosion;” however, the rules do not directly address the desired outcome, which is to avoid resource damage. In addition, the rules do not offer a standard process for landowners and regulators to assess or identify successes and failures relating to resource protection which can lead to varying compliance expectations throughout the state for landowners, regulators, and the public. The draft report by the DNR on road maintenance concluded that the current rules emphasize the use of culverts and ditches as the primary means of addressing hydrologic issues, but do not adequately address sediment production. The results of the survey showed that approximately 65 percent of the survey areas had direct delivery of sediment from roads to streams (DNR, unpublished draft report, 1999).

In addition, the rules under Alternative 1 do not result in a landscape-level approach to sediment reduction. The rules do not encourage the reduction of road drainage into streams. Road maintenance and abandonment plans, which are more of a landscape-level assessment, are not mandatory unless DNR assessments indicate an ongoing problem; in this situation, road plans are required on a case-by-case basis. The rules under Alternative 1 do not have any specific guidelines or assessment tools in the Board Manual as to when these plans are required. The draft report by the DNR on road maintenance concluded that road maintenance and abandonment plans appear to assist landowners in identifying and addressing most issues that have the potential to cause resource damage and are effective at providing better protection for public resources; however, surface erosion appeared to be a problem in some areas that had a road maintenance and abandonment plan (RMAP) (DNR, unpublished draft report, 1999).



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Alternative 2 would substantially reduce road-related sediment from delivering to streams due to: 1) improved BMPs and 2) implementation of RMAPs, and 3) an outcome-based and enforceable policy statement that requires resource protection. However, monitoring is necessary to verify the resource protection required by an outcome-based policy.

ALTERNATIVE 2

Under Alternative 2, the BMPs recommended in the Board Manual are expected to substantially reduce sediment delivery to streams relative to Alternative 1. Like Alternative 1, many of the BMP guidelines would be prescriptive; however, the revised outcome-based policy statements under Alternative 2, requires whatever measures are necessary to protect water quality and aquatic/riparian habitats (see Appendix F).

The approach of the rules under Alternative 2 is specifically designed to reduce road-generated sediment. For new roads, all ditch relief culverts would be required to empty onto the forest floor in such a way that no sediment reaches a stream. Research has shown (Duncan et. al, 1987) that outfall sediment can travel overland for 100 feet (or more) under certain conditions. Therefore, Alternative 2's requirement for ditch relief culverts will result in placement of the culvert at least 100 feet from any stream. Other conditions, such as slope and soil texture, could make the culvert-to-stream distance even greater. Road maintenance and abandonment plans would be required by 2005 of landowners with more than 500 acres of forest land. They would require the inventory and assessment of all forest roads, including orphan roads. Further, the rules under Alternative 2 specify that all upgrades to roads must be completed, and new maintenance standards applied to all roads built after 1974 by the end of 2015. Priorities in the rules place activities and locations with the highest potential benefit to fish and water quality early in the maintenance and abandonment schedule. The DNR provides guidance and tools necessary for landowners to complete the road maintenance and abandonment plans.

The road maintenance and abandonment plan represents a landscape-level approach that includes prioritization of problem sediment areas and temporal components for completion that would reduce the delivery of chronic sediment to streams. Abandonment plans would prioritize roads for abandonment that would exempt them from future maintenance. This would also result in further reduction of surface erosion sediment delivery to streams.

The road policy to protect water quality and aquatic riparian habitats does not explicitly include or recommend tools such as monitoring to measure the effects of roads on the resources. As a result, there is no systematic way to determine whether the policy or goals will be attained in a given watershed under Alternative 2. However, general effectiveness monitoring will occur through the adaptive management program and the proposed rules require annual reviews of road plans and meetings with landowners which are likely to include an assessment of the plan's effectiveness.

There is great difficulty associated with implementing a cost- and time-efficient monitoring plan that can verify the attainment of resource goals (e.g., in order to verify that new ditch relief culverts do not deliver any sediment to streams, intensive monitoring may need to be conducted during rainy periods). Consequently, the adaptive management program intends to focus effectiveness monitoring within representative watersheds to obtain a higher likelihood of collecting meaningful data rather than a lower level of monitoring dispersed over a wider area (M. Hunter, WDFW, personal communication, January 19, 2001) .



Alternative 3 would produce a low risk of road-generated sediment from entering streams over the short-term, as well as over the long-term, because of the restriction on increasing road densities and the shorter timeframe for completion of RMAPs; otherwise, it would be similar to Alternative 2.

Alternative 1 would result in a continued moderate risk of road-related landslides because:

- 1) the unstable slope screening process does not identify some unstable areas;
- 2) the rules and BMPs that address road drainage are inadequate; and
- 3) there are generally no requirements for RMAPs.

ALTERNATIVE 3

Alternative 3 would substantially reduce road sediment delivery to streams relative to Alternative 1. There would also be a reduced risk of road sediment delivery to streams under Alternative 3 compared to Alternative 2. This is primarily due to the requirement of no net increase in forest road densities on state and private timberlands. In addition, Alternative 3 would require orphan roads to be maintained or abandoned and would eliminate sources of chronic sediment where these roads deliver sediment to streams. In addition, the time frame for road maintenance and abandonment plan completion by 2010 would be 5 years shorter than under Alternative 2. Road upgrades and road abandonment in a shorter time period would reduce the total quantity of sediment generated by surface erosion compared to Alternative 2.

Road-related Landslides

ALTERNATIVE 1

Under Alternative 1, road-related landslides would continue to occur at their current rate and deliver episodic quantities of sediment to streams. The construction of roads on potentially unstable slopes increases the risk of road-related failures (as mentioned above). Landforms with a high potential for mass wasting would most likely be identified in forest practices applications (FPAs) and classified as Class IV-special. A Class IV-special forest practices application covers practices where there is a potential for substantial impact to the environment such as aquatic habitat, water quality, and cultural resources (see Section 1.4.1). Because of the rudimentary screening tools used to identify unstable areas, there is a greater likelihood that potentially unstable areas may be missed in the application process.

The current rules also have few specific guidelines that directly address road-related mass wasting issues such as road drainage. Road-related landslides can be caused by road drainage problems such as plugged culverts and inadequately spaced cross drains and/or roads construction on potentially unstable slopes. Problems can result from inadequate construction and maintenance. The rules under Alternative 1 require culverts and bridges that cross streams to pass a 50-year flow event. Cross drains are only required every 600 to 1,000 feet depending on road grade. A recent draft report by the DNR on road maintenance concluded that the most common drainage problems that caused resource damage to streams were undersized culverts and inadequate cross drain spacing; the most common maintenance related drainage problem was the maintenance of functional inlets (i.e., the drains from roadside ditches that divert water under the road through a culvert).

In addition, the current rules do not address drainage onto unstable slopes. Road drainage onto unstable areas can initiate mass wasting and the drainage onto unstable areas may not be identified when an FPA is reviewed; thus, a road built on stable ground may drain water onto potentially unstable areas. The drainage of water onto steep slopes can increase the risk of slope failure. Where watershed analysis has been conducted, the prescriptions for mass wasting would address and reduce the risk of road-related landslides.

Studies by Toth (1991) and ODF (1999) found that newer roads (younger than 10 years old) experienced a lower rate of mass wasting than older roads. Because there is no



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requirement under the Alternative 1 rules to upgrade roads to current construction standards unless a public resource has been damaged, the thousands of miles of older roads (both active and inactive) and orphan roads would continue to fail over time and deliver large quantities of sediment to the drainage network. If roads or orphan roads are damaging public resources, the DNR has the authority to require the repair of these roads.

Alternative 2 would result in a low to moderate risk of road-related landslides because:

- 1) the unstable slope screening process would be refined;
- 2) the rules and BMPs that address road drainage would be substantially strengthened; and
- 3) RMAPs would be required.

ALTERNATIVE 2

Under Alternative 2, new roads built on potentially unstable slopes would require greater scrutiny if the forest practices application is processed as a Class IV-Special. Class IV-Special applications would require a specific SEPA review including a site evaluation by a qualified expert and a detailed mitigation plan (see Appendix E for more details). In addition, a more refined screening method would be used to identify potentially unstable slopes that have a potential hazard of delivering sediment to public resources. This more refined screening process would reduce the risk of road construction on high hazard mass wasting areas and reduce the potential of failure on slopes and landforms with a high hazard failure potential.

Road drainage guidelines in rules under Alternative 2 would reduce drainage-related road failures such as plugged culverts. There are more specific BMPs in the rules that address road drainage. Some of these include: outsloping roads so more runoff drains onto slopes, improved cross-drain spacing, and installation of new culverts that can pass a 100-year flow event. Maintenance BMPs include removing debris from culvert outlets and inlets after major storm events and preventative ditch maintenance.

The BMPs under Alternative 2 fail to consider that roads located on stable slopes may drain onto potentially unstable slopes (e.g., a ridge-top road that drains water onto convergent headwalls) without initiating a Class IV-Special application. This omission represents a risk of mass wasting which has been documented in a study by Montgomery (1994).

Under Alternative 2, an existing culvert will be replaced unless it meets the following three requirements: (1) pose "little risk to public resources"; (2) "have been properly maintained"; and (3) be "capable of passing fish" (WAC 222-24-050). The RMAPs to be implemented under Alternative 2 are intended to prevent failure of existing culverts by requiring maintenance and replacement of culverts that pose a significant threat to public resources. There are many existing culverts on type N_p and N_s streams. If damage to public resources is imminent, the existing culvert must be replaced sooner, rather than later. However, if a culvert passes the three requirements mentioned above, the culvert does not need to be replaced to meet upgraded standards until the end of its lifespan.

The required RMAPs would result in landowners with over 500 acres of forested land to upgrade all roads on their ownership by 2015. Landowners with less than 500 acres would submit a RMAP with next forest practices application. This would improve all roads to current construction standards, which has been demonstrated by Toth (1991) and ODF (1999) to have a much lower rate of mass wasting (e.g., failure) than older roads. The use of RMAPs would substantially reduce the risk of road-related landslides compared to



Alternative 3 would result in the lowest risk of road-related landslides because:

- 1) there would be no net increases in roads;
- 2) the rules and BMPs that address road drainage would be substantially strengthened; and
- 3) RMAPs would be required in the shortest timeframe.

Alternative 1 would result in a moderate risk of harvest-related landslides delivering to streams, primarily due to the low frequency of RMZ protection along steep Type 4 and 5 streams.

Alternative 1. Orphan roads would be inventoried and assessed. After the inventory and assessment, the maintenance and/or abandonment of orphan roads would be conducted by 2015. Where orphan roads are abandoned, there would be further reduction of potential mass failure of roads, sediment delivery to streams, and potential debris torrent initiation.

ALTERNATIVE 3

The potential risk for road-related mass wasting would be less than under Alternative 2. The no net increase in roads on a per unit basis would reduce the risk of failure because fewer roads would be constructed. In addition, the time frame for RMAPs and the upgrade of older roads to current construction standards would occur over a shorter time frame (10 years) than Alternative 2. The shorter time period for the RMAPs, which include the maintenance of orphan roads, decreases the potential road failures because the potential for failure of older roads would be reduced by 5 years. Roads on stable slopes that drain onto potentially unstable slopes would not be classified as Class IV-Special applications, resulting in the same risk of mass wasting from this impact as under Alternative 2. Alternative 3 would result in an overall reduction of road-related sediment from entering the drainage network.

Landslides Related to Timber Harvest

ALTERNATIVE 1

Under Alternative 1, some landforms with a high potential for mass wasting would most likely be identified during processing of the forest practices application. Due to the rudimentary methods used to screen for unstable areas, there is a greater likelihood that potentially unstable areas may be missed in the application process. In addition, there is little incidental protection of potentially high hazard slopes under Alternative 1 because there are no RMZs for Type 4 and 5 waters, which constitute approximately 80 percent of all streams on the landscape. RMZs of fish-bearing typed waters (Type 1, 2, and 3) provide some incidental protection of areas with a high hazard mass wasting potential; however, the effectiveness of these buffers may be impaired by short-term losses to windthrow.

Under Alternative 1, the only protection provided for small channel junction angles and steep channel gradient slopes would be if they triggered a Class IV-special application based on appearing to be unstable and having a potential to significantly impact a public resource. Because these areas receive no specific protection, there is a moderate risk of debris torrents. The steep small tributary streams tend to be first- and second-order streams that would be Type 4 and 5 waters. These streams have no buffers to protect them from management activities.

Once a debris flow is initiated, the RMZs of higher order streams may act to reduce the channel impacts. The streams most susceptible to riparian damage by channelized debris flows tend to have gradients greater than 20 percent. On the westside, approximately 95 percent of all streams with gradients greater than 20 percent are Type 4 and 5 waters; these streams would receive no buffer protection of riparian damage by channelized debris flows. Lower gradient streams (Types 1-3) would receive some (though probably minimal in some cases) protection against riparian damage by dam-break floods under the existing



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RMZ. This alternative would have a moderate risk of harvest-related landslides delivering to streams.

Alternative 2 would provide greater protection relative to Alternative 1, but would still result in a slight to moderate risk of harvest-related landslides delivering to streams. The risk would result from the lack of RMZs on many steep nonfish-bearing headwater streams.

ALTERNATIVE 2

Under Alternative 2, 5 percent of slopes with a high potential for failure would be incidentally protected by the RMZs based on modeling (see Appendix E). The Class IV-special process (see Section 1.4.1) provides additional environmental review of forest practices on slopes considered to have a high potential to damage public resources or threaten public safety. Currently, there is training of field personnel in the identification of high hazard features as a voluntary commitment of the Forests and Fish Agreement. The greater environmental review should reduce the risk of timber-harvest related mass wasting and potential sediment delivery to streams.

The forested landscape would be subject to more sophisticated screening methods statewide that would account for regional and local variations in soils, geology, and topography. Because the screening tool would be more likely to identify potentially unstable slopes that may affect public resources and/or safety, more applications would be classified as Class IV-special by DNR. In addition, more extensive unstable slope identification training of DNR personnel will also reduce the risk of management activities on potentially unstable slopes. These changes are not rule-based, but rather agency tools used to implement the rules and protect public resources. As a result, the rule-based language of Alternative 2 slightly reduces the risk of management-related mass wasting compared to Alternative 1 because of the greater likelihood of environmental review under SEPA.

Under Alternative 2, areas of high susceptibility to debris torrents (i.e., steep tributary junctions) would receive greater protection than under Alternative 1. If the areas of high susceptibility are on specific geomorphic landforms considered to be highly unstable and have the potential to deliver sediment to a public resource or threaten public safety, a Class IV-Special classification would be required and mitigation might be necessary for the management activity to occur. In addition, perennial nonfish-bearing streams (Type N_p) that intersect would have a 56-foot radius no-harvest buffer. Sensitive areas such as headwall and sideslope seeps, springs, and alluvial fans would also receive a 56-foot radius no-harvest protection. Seasonal nonfish-bearing streams (Type N_s), as well as unbuffered perennial streams (Type N_p) would receive protection from equipment limitation zones (ELZs). Management activities are allowed in ELZs, but with specific mitigation requirements for any soil disturbance greater than 10 percent of the ELZ area. Local buffer effectiveness may be impaired in some cases due to short-term losses to windthrow. There is still a moderate risk of debris torrent initiation because of potential for management activity in areas of susceptibility.

Approximately 25 percent of streams less than 20 percent gradient would have Type S and F buffers and 75 percent would have Type N buffers. These buffers would provide some, but not full fencing effect for debris torrents, and may be subject to short-term losses to windthrow. As a result, Alternative 2 would have a slight to moderate risk of harvest-related landslides delivering to streams.



Alternative 3 would provide much greater protection relative to Alternatives 1 and 2 and would result in only slight risk of harvest-related landslides delivering to streams because all streams would have RMZs, and small steep streams would have CMZs.

ALTERNATIVE 3

Under Alternative 3, 14 percent of high hazard slopes would be incidentally protected by no-harvest RMZs (based on modeling) (see Appendix E). In addition, potentially high hazard areas identified in advance would automatically trigger a Class IV-special classification and would receive a 50-foot no-harvest buffer. Alternative 3 provides the most protection from mass wasting and delivery of sediment to streams due to timber harvest.

The no-harvest RMZs under Alternative 3 would protect steep stream channel junctions. This would probably reduce the frequency and downstream impacts of debris torrents. Also, there is no timber harvest or road activity permitted on high hazard slopes. Incidental protection of steep tributary junctions would also be provided if the tributary junction areas are considered high hazard mass wasting areas. Streams with channel gradients of 20 to 30 percent would be buffered by 100 feet and streams with gradients greater than 30 percent would receive 70-foot buffers. Further, additional CDZ buffers would be added along steep streams, with expected channelized landslides. These buffers should provide a fencing effect from potential debris torrents. Because buffer widths are wider under Alternative 3, they are more likely to be sufficiently windfirm and thus more likely to function fully and without short-term losses to blowdown.

Hillslope Erosion Related to Timber Harvest

ALTERNATIVE 1

Alternative 1 would result in nearly full protection of hillslope erosion from directly reaching Type 1, 2, and 3 waters. The lack of RMZs along Type 4 and 5 streams would result in a high risk of hillslope erosion delivering sediment to these waters.

Under Alternative 1, the risk of sediment delivery to streams is greatest along Type 4 and 5 streams, which do not have RMZs. Because Type 4 and 5 streams are the most abundant streams on the landscape, the risk of sediment delivery from harvest-related practices would be high. The sediment EBAI is lowest for Alternative 1 because of the lack of riparian buffers necessary to filter harvest-related surface erosion (Figure 3.2-2). Sedimentation would be short-term until sites become revegetated. Alternative 1 provides an EBAI (see Appendix D) which is 64 percent (weighted by stream type) of the value for maximum protection (Figure 3.2-2). This weighted value is a reflection of high protection along Type 1-3 streams and virtually no protection along Type 4 and 5 streams, which accounts for the majority of stream miles within the affected lands.

In a study on the effectiveness of the existing forest practice rules at preventing sediment delivery, Rashin et al. (1999) concluded that streamside buffers (RMZs and Riparian Leave Tree Areas) were effective at preventing sediment delivery to streams on Type 1-3 streams. Along Type 4 and 5 streams, which are not buffered, physical impacts included extensive fine sediment deposition and other streambed changes such as increased streambed mobility, burial of substrates by logging slash, and loss of pre-existing large woody debris. Rashin et al. (1999) concluded that no-harvest buffers in place at the time, were generally effective in preventing sediment delivery, except where flow was channelized. Most erosion features that were identified as delivering sediment, occurred within 30 feet of a stream. However, they concluded that many of the BMPs and rules were ineffective, particularly where there was no RMZ, as for Type 4 and 5 streams. In another study,

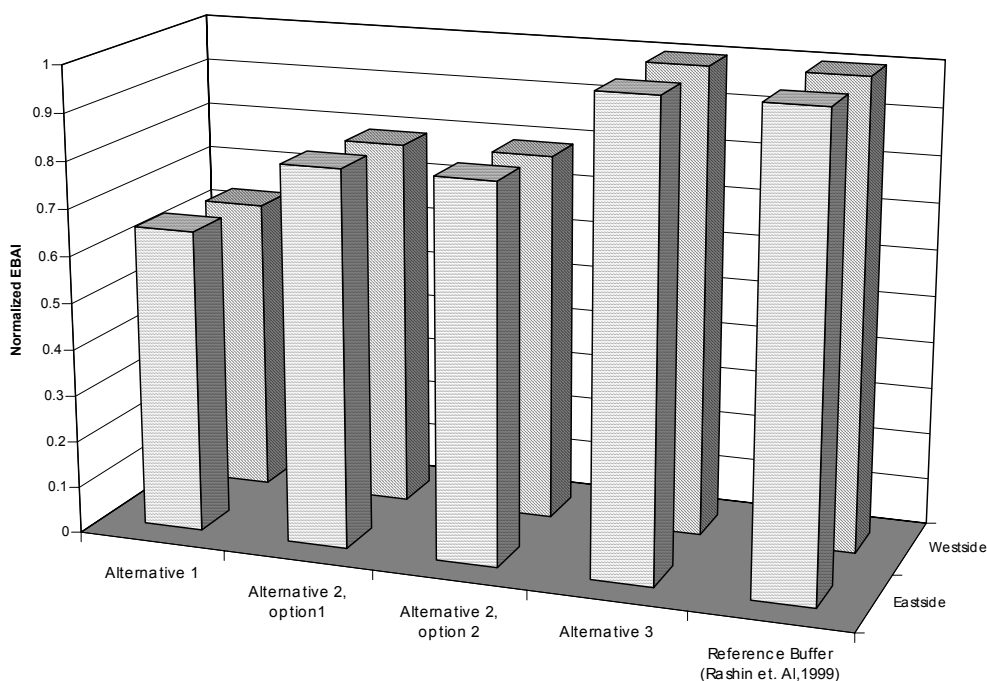


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Pentec (1991) pointed out that lack of an RMZ and associated BMPs on Type 4 and 5 streams was a fundamental conceptual flaw in the forest practices rules.

In the representative sample area used for the analysis in this EIS, Types 4, 5, and 9 (west side only) streams comprised approximately 80 percent of the total stream length. The risk of sediment delivery to these and other larger streams would be high under this alternative.

Figure 3.2-2. Equivalent Buffer Area Index (EBAI) for Sediment by Alternative





ALTERNATIVE 2

Alternative 2 would result in full protection of hillslope erosion from reaching Type S and F streams. However, there is a low risk of sediment from hillslope erosion entering Type N_p and N_s streams.

Under Alternative 2, the no-harvest portion of RMZs for Type S and F streams (a minimum of 50 feet on the westside and 30 feet on the eastside) meet or exceed the 30-foot buffer criteria necessary to filter any management-related sediment generated from adjacent harvest units or activities within the RMZs. There is full protection of hillslope erosion along Type F and S streams.

A 30-foot ELZ on each side would be applied to all Type N_s and N_p streams. Landowners must mitigate (e.g., grass seeding, mulching, or installation of water bars) for the disturbance of more than 10 percent of the soil within any ELZ as a result of the use of ground-based equipment, skid-trails, stream-crossings (other than road crossings), or partial suspension of logs during yarding. These ELZs should substantially reduce the amount of timber harvest-generated surface erosion and subsequent delivery to the stream network. Notably, there is no monitoring requirement; monitoring is necessary to determine the effectiveness of erosion control measures.

Approximately 50 percent of the N_p streams on the westside would receive 50-foot no-harvest buffers, which exceeds the 30-foot sediment filtration criterion. In addition, sensitive areas, such as seeps, hyporheic zones, and areas upstream from the confluence with Type S and F waters, would also have 50-foot no-harvest buffers. The no-harvest buffers along many of the N_p streams, and the 30-foot ELZ along the other Type N_p streams and N_s streams should prevent hillslope sediment from entering streams.

Along Type N_p streams on the eastside, if the clearcut option is chosen by a landowner, approximately 70 percent would receive a 50-foot no-harvest buffer. If the partial cut option is chosen, a 50-foot selective harvest buffer would be required. In the cases where activity is allowed, the effectiveness of the RMZ in filtering sediment is compromised, but the mitigation requirements should be effective in reducing any surface erosion from entering streams.

The EBAI for effective function of riparian sediment filtration shows that Alternative 2 would have a greater buffering effect for sediment filtration (80 percent of maximum) compared to Alternative 1 (Figure 3.2-2). However, it does not provide full protection of timber harvest-related surface erosion, specifically along Type N_p and N_s streams that do not have 50-foot no-harvest buffers.

ALTERNATIVE 3

Alternative 3 would provide full protection of all streams from timber harvest-related hillslope erosion.

The no-harvest buffers on all stream types far exceed the 30-foot buffer criteria. Therefore, all streams should be fully protected from hillslope erosion delivery of sediment. The EBAI for this alternative (100 percent of maximum) is the greatest among the alternatives (Figure 3.2-2).



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Effects of Timber Harvest on Bank Stability

ALTERNATIVE 1

Alternative 1 would generally protect bank stability along Type 1, 2, and 3 streams. However, bank stability would not be protected along Type 4 and 5 streams; therefore, a high risk of bank instability would exist along these small streams.

In western Washington, Alternative 1 (current forest practices rules) would provide full protection for bank stability based on the RMZ buffer widths for Type 1, 2, and 3 streams when maximum RMZ widths are implemented. However, the minimum RMZ width of 25 feet does not meet the one-half crown diameter (0.3 SPTH) required for complete protection of bank stability (Figures 3.4-7 and 3.4-8). For each stream type, RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation and the width needed for shade. Also, selective harvest would likely be implemented adjacent to the stream channel, compromising the combined root strength and increasing the risk of damage to the stream bank directly from timber harvest activities. However, a greater number of leave trees are provided in RMZs along less stable stream channels (i.e., gravel/cobble channels) and this aspect may reduce the risk of bank failure. For streams that do not meet the established criterion of one-half crown diameter (0.3 SPTH), combined with the selective harvest prescriptions, the risk of reducing stream bank stability would increase.

In eastern Washington, full protection would be provided along Type 1, 2 and 3 streams when implementing the maximum and average RMZ widths. One exception is for site class I, which would require a greater RMZ to provide a sufficient width buffer to maintain bank stability. However, minimum RMZ widths of 30 feet provide complete protection of bank stability for all other site classes (Figure 3.2-1).

As for western Washington, the possibility of harvest activity within the RMZ under Alternative 1 leaves the possibility that root strength would be compromised and the stream bank potentially damaged. However, selective harvest does maintain some stream bank integrity through root strength and minimizes stream bank damage relative to clear-cutting.

The greatest risk is for Type 4 and 5 streams that have no leave tree requirement and where timber harvest can occur adjacent to the stream. For Type 4 and 5 waters, RMZs are not required except for site-specific conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the one-half crown diameter (0.3 SPTH) required for complete protection under the maximum protection provided by the current forest practices rules. Type 4 and 5 streams are smaller, tend to be moderately or highly confined, and have less erosive power; therefore, they do not necessarily require expansive buffers for bank stability protection. However, Type 4 and 5 streams are susceptible to other processes such as mass wasting and peak flows, which could also affect bank stability. The lack of an RMZ along most of these smaller streams means that Type 4 and 5 waters would receive no bank stability protection.

Alternative 2 would protect bank stability, except along many non-fish streams which lack RMZs. However, some protection would be provided by ELZs.

ALTERNATIVE 2

Under Alternative 2, all Type S and F streams would have RMZ widths that exceed the width recommended in the literature for full protection of bank stability. On the westside, the 50-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the selective harvest inner zone under Option 1, should provide sufficient bank stability



protection. Additional protection due to the no-harvest floor adjacent to the 50-foot no-harvest zone under Option 2 would provide even greater protection of bank stability. On the eastside, the 30-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the selective harvest inner zone should provide sufficient bank stability protection. Overall, Alternative 2 would provide substantially more bank stability protection than Alternative 1 along Type S and F streams.

For Type N_p streams, at least 50 percent of their lengths would receive a 50-foot RMZ; these segments would have most of the protection required to maintain bank stability. In addition, Type N_p streams are much smaller, tend to be moderately or highly confined, and have less erosive power; therefore, they do not necessarily require buffers as wide for bank stability protection. For other segments of Type N_p streams and for all N_s streams, no RMZ would be provided. However, all Type N streams would receive some protection because of the 30-foot equipment limitation zones that would be implemented. These zones provide more protection than Alternative 1. However, lack of an RMZ restricting tree harvest on these smaller streams would indicate that some Type N_p and all N_s streams are not guaranteed complete bank stability protection.

ALTERNATIVE 3

Alternative 3 would fully protect bank stability along all streams.

Under Alternative 3, the RMZ width and no-harvest prescription would meet or exceed the recommendations in the literature (0.5 SPTH no-harvest buffers) for full protection of stream bank stability on most streams. Overall, for all streams on both the east and westside, bank stability would be completely protected. In addition, where there are small channels that have potential slope stability issues, channel disturbance zone buffers would provide additional protection.



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